DOCUMENT RESUME

ED 189 066 SP 016 260

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TITLE Learning by Doing, Vintage, and Selection: Three Pieces of the Puzzle Relating Teaching Experience and Teaching Performance.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C. Finance and Productivity Group.
PUB DATE Mar 80
CONTRACT 400-76-0157
NOTE 23p.; Paper presented at the Annual Meeting of the American Educational Research Association (Boston, MA, April, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academically Gifted; Educational Quality; Faculty Mobility; *Job Performance; Labor Market; Research Methodology; *Teacher Effectiveness; *Teacher Selection; *Teaching Experience

ABSTRACT

This paper points out that the puzzling nature of the evidence concerning the relationship between teaching experience and teaching performance is due in part to the research methodology used to study this relationship. Cross-sectional data reflects three different phenomena: learning by doing, teachers' academic excellence, and influence of the job market on selection of teachers. It is explained how these phenomena influence the relationship between experience and performance observed in a cross-section of teachers. It is suggested that teachers' academic excellence has a marked effect on the estimated impact of learning by doing on teaching performance. (Author/JD)

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LEARNING BY DOING, VINTAGE, AND SELECTION: THREE PIECES OF THE PUZZLE RELATING TEACHING EXPERIENCE AND TEACHING PERFORMANCE

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March 31, 1980

Paper delivered at the Boston meetings of the American Educational Research Association April, 1980.

This research was supported by the Finance and Productivity group of the National Institute of Education under Contract No. 400-76-0157, awarded to Mathematica Policy Research. It does not, necessarily reflect the views of the National Institute of Education.

SP018260

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ABSTRACT

This paper points out that the puzzling nature of the evidence concerning the relationship between teaching experience and teaching performance is due at least in part to the research methodology used to study this relationship, in particular to the use of cross-sectional data on teachers. With cross-sectional data, the variable of interest, years of teaching experience, reflects three different phenomena: learning by doing, vintage, and selection. We explain these phenomena and indicate how they influence the relationship between experience and performance observed in a cross-section of teachers. We then show how explicitly taking into account one of the factors, vintage, has a marked impact on the estimated impact of learning by doing on teaching performance.

I. INTRODUCTION

The question of whether teachers become more productive as they gain teaching experience has been of interest to policymakers for many years. One reason is that schools serving children from low income families have typically been staffed with less experienced teachers than schools serving middle class children (Owen, 1972). This has led to court tests of whether the uneven distribution of teaching experience constitutes discrimination against low income children (Hobson v. Hansen, 1967).

Unfortunately, efforts to model and estimate the relationship between teaching experience and teaching performance have not been very helpful to policymakers and the courts. Despite a growing number of studies, the evidence remains inconclusive. Some educational production function studies report significant positive relationships between teaching experience and teaching performance, as measured by student achievement gains (Hanushek, 1972; Murnane, 1975). Other studies report no significant relationships (Hanushek, 1971; Henderson et al., 1978; Link and Ratledge, 1979).[1/]

This paper points out that the puzzling nature of the evidence is due at least in part to the research methodology used to study this relationship, in particular to the use of cross-sectional data on teachers. With cross-sectional data, the variable of interest, years of teaching experience, reflects three different phenomena: learning by doing, vintage, and selection. We explain these phenomena and indicate how they influence the relationship between experience and performance observed in a cross-section of teachers. We then show how explicitly taking into account one of the factors, vintage, has a marked impact on the estimated impact of learning by doing on teaching performance.

II. THREE FACTORS INFLUENCING THE EXPERIENCE-PERFORMANCE RELATIONSHIP

A. Learning by Doing

The hypothesis that teachers become significantly more effective as they gain experience rests on the view that teaching is a complex process requiring a varied set of skills, many of which can only be learned on the job. In other words, teachers learn to teach by teaching, and as a result, they become more effective as they acquire experience. The most straightforward way to investigate the impact of learning by doing on teaching performance is to examine the effectiveness of individual teachers over time. To date this strategy has not been used.

Instead, the role of learning by doing has been investigated by estimating the relationship between experience and performance in a cross-section of teachers. It has been implicitly assumed that inclusion in the model of information on the background and training of each teacher accounts for differences in the effectiveness of teachers due to factors other than learning by doing. However, there are good reasons why significant unobserved differences in the innate talents of teachers with different levels of experience may exist that lead to bias in the estimated impact of learning by doing. These differences can be characterized as vintage and selection effects.

B. Vintage Effects

Vintage effects are defined as differences in the average abilities of teachers hired by school districts at different points in time.[2/] The most compelling explanation for the existence of vintage effects is that dramatic changes in labor market conditions for teachers over the last twenty-five years have affected the quality of

new entrants to the teaching profession. In the late 1950's and early 1960's, a rapid increase in student enrollments created an acute shortage of teachers in the United States. Many school districts, particularly urban districts, found it difficult to find minimally qualified applicants to fill vacant positions. By 1970 this situation had changed significantly. Due to the combination of a decrease in the demand for teachers precipitated by declining enrollments and an increase in the supply of teachers (a delayed response to the earlier shortage), there has been a surplus of teachers in most subject areas during the 1970's. As a result, school districts have been able to be very selective in choosing among the large number of applicants for teaching positions. Assuming that district personnel officers are able to identify applicants with the greatest potential, the average quality of new teachers should be higher in periods of excess supply, such as the 1970's, than in periods of excess demand, such as the early 1960's.[3/] Unless the differences in the average abilities of teachers are captured by variables describing teacher backgrounds (which is very difficult to do), these differences will confound the estimate of the impact of learning by doing.

C. Selection Effects

Selection effects are defined as differences between the average abilities of teachers of a given experience level who choose to remain classroom teachers and those who choose to leave classroom teaching. There are a variety of mechanisms which could create significant selection effects. For example, the more effective experienced teachers may leave the classroom to become administrators. Similarly,

it may be only the most able first year teachers who survive the discipline problems that plague new teachers. If selection effects such as these result in the best experienced teachers leaving the classroom, and the best inexperienced teachers remaining in the classroom (until they acquire enough experience to become administrators), then the estimated relationship between experience and performance for a cross-section of teachers will underestimate the impact of learning by doing.

Another source of selection is that many teachers leave the classroom to take positions in professions in which salaries do not depend on degrees and experience. Effective teachers may be the most likely to leave since their teaching ability may reflect skills valued in other professions. Without knowing how many years teachers are likely to spend in the classroom before switching professions, it is not possible to infer how this selection mechanism affects the observed relationship between teaching experience and performance.

We conjecture that many of the inconsistencies in the educational production function literature concerning the relationship between teaching experience and teaching performance are due to vintage and selection effects, the direction and magnitude of which depend on the date at which the data were collected and on the history of labor market conditions in the sample area.

Unfortunately, with the data available to us (and to our knowledge, to any other researchers), it is not possible to examine the role of selection effects. However, using micro data on teachers in one large urban school district, it is possible to construct a variable that provides an explicit indicator of vintage effects. The

next section describes the data base and the variables used to indicate learning by doing and vintage effects.[4/]

III. DATA AND MODEL

The data used in this study consist of information on students and teachers in a large city in the Midwest in the mid 1970's. All of the children are black children attending the third or fourth grade in inner city schools.[5/] Ninety-three percent of the teachers are black. The data have the following desirable attributes:

1. The unit of observation is the individual child.
2. Longitudinal information on each child's achievement is used. The measures of achievement are scores on the vocabulary subtest of the Iowa Test of Basic Skills. Scores are available for successive school years for each child.
3. Detailed data on each child's home environment, including family income and number of siblings, are included.
4. Each child is matched to his or her individual classroom teacher.
5. The data on each teacher include information on training and experience as well as the date at which each teacher began to work in the school system.

The primary hypothesis investigated in the empirical work is that explicit analysis of vintage effects will increase the estimated impact of learning by doing. The variable used to indicate vintage effects is the change in total student enrollments in the district between the year in which the teacher first taught in the district and the previous year. The logic underlying the use of this variable is that in years of rapidly growing student enrollments, this district and neighboring districts competing for teachers in the same labor market hired large numbers of

teachers at a time in which the supply of teachers was relatively limited. As a result, they could not be selective in choosing among applicants. When enrollments were declining, personnel officers could be more selective and average teacher quality would rise. This logic led to the second hypothesis: namely, that the coefficient on the variable measuring changes in student enrollments would have a negative sign, indicating that teachers hired when enrollments were growing would be of lower average quality than teachers hired in periods of declining enrollments.

The variable included in the model to indicate learning by doing was the natural logarithm of each teacher's total number of years of teaching experience. This specification reflects the assumption that teachers continue to learn as they gain experience, but that the greatest gains from additional experience occur in the first years of teaching.

It is important to note that the sample contains teachers hired over the thirty year period from the early 1940's to the early 1970's. As Table A-1 in the appendix indicates, there were wide swings in enrollments during this period. During the 1940's, student enrollments were relatively stable. Enrollments grew rapidly during the 1950's and more slowly during the 1960's, reaching a peak in 1968. After 1968, student enrollments decreased steadily. The nonmonotonic changes in student enrollments created a significant amount of independent variation between the variable indicating vintage effects and the variable indicating learning by doing. Further variation was created by the fact that more than 15 percent of the teachers had taught in other school systems. For these teachers, the total number of years of teaching experience was not simply equal to the difference between 1975, the date when the data were collected, and the

date when the teacher was hired by the school system. As a result of these factors, the zero order correlation coefficient between the variable indicating vintage effects and the variable indicating learning by doing was only 0.51. This was sufficiently low to permit separate estimation of the impacts of learning by doing and vintage effects on teaching performance (as measured by the achievement test gains of students).

These coefficients were estimated in the context of a linear model with the following general form:[6/]

$$A_{it} = a_o + a_1 A_{i,t-1} + \sum_j h_j H_{ij} + \sum_m t_m T_{im} + eE_i + vV_i + u_i \qquad (1)$$

where

A_{it} = the achievement level of the ith child at the end of school year t

$A_{i,t-1}$ = the achievement level of the ith child at the end of school year t-1

H_{ij} = the jth characteristic of the ith child or his family

T_{im} = the mth characteristic of the ith child's teacher (excluding experience)

E_i = natural logarithm of the number of years of experience of the ith child's teacher

V_i = total student enrollments in the school system in the year in which the ith child's teacher first worked in the system minus student enrollments in the previous year

u_i = a disturbance term that has a zero mean and constant variance.

Summary statistics describing the distributions of the variables included in the model are presented in Table A-2 of the appendix. The model was estimated using ordinary least squares.

IV. THE RESULTS

As Column 1 of Table 1 indicates, when the impact of learning by doing was estimated in a model that did not include an indicator of vintage effects, the estimated coefficient was positive, but not significantly different from zero.

Insert Table 1

However, as Column 2 indicates, when the indicator of vintage effects was included in the model, the impact of learning by doing more than doubled, and the estimated coefficient was significantly different from zero at the .01 level. The size of the estimated coefficient, when translated into grade equivalents, implies that children taught by a teacher with five years of experience make three to four more months of progress in acquiring reading skills during a school year than do children taught by a first year teacher. Thus, the estimated results provide support for our first hypothesis: that the effect of learning by doing becomes more pronounced when vintage effects are explicitly taken into account.[7/]

As Column 2 indicates, the empirical results also provide support for the second hypothesis: that the coefficient indicating the impact of vintage effects would be negative and significantly different from zero. Thus, the results indicate that learning by doing and vintage effects are both significant determinants of the quality of the teaching staffs in a large urban school district.

V. IMPLICATIONS FOR THE FUTURE

If the relationships estimated in this model continue to hold in the future, teachers hired in the next few years should be of high average quality. The reason is that enrollments will continue to fall over the

Table 1

ESTIMATED PARAMETERS OF EQUATION 1

* indicates significance on a 5% two-tailed t test.

** indicates significance on a 1% two-tailed t test.

Indicator of Vintage Effects		
Student enrollments (in hundreds of students) in the school district in the year in which the teacher began work in the district minus student enrollments (in hundreds of students) in the previous year		-1.19** (-2.70)
Teacher Characteristics		
Natural log of the total number of years of teaching experience (indicator of learning by doing)	12.03 (1.39)	25.65** (2.58)
Holds master's degree	-6.72 (-0.76)	-2.94 (-0.33)
Attended prestigious college	-10.15 (-1.06)	-2.52 (-0.26)
Teacher is male	-0.02 (-0.00)	4.87 (0.19)
Teacher is white	5.19 (0.25)	4.30 (0.21)
Student Background Characteristics		
Student is male	22.93** (2.86)	24.19** (3.04)
Current family income	0.02 (0.97)	0.01 (0.88)
Student's age	-8.63 (-1.26)	-8.19 (-1.20)
Household head is female	6.45 (0.70)	6.25 (0.68)
Number of children in the family	-4.01* (-2.00)	-3.93* (-1.98)

Student Achievement at End of Previous Year		
Achievement level of child in third grade at end of previous year	0.75** (12.01)	0.74** (12.01)
Achievement level of child in fourth grade at end of previous year	0.84** (9.32)	0.86** (9.58)
R^2 [a/]	0.49	0.50

a/ Separate intercepts were estimated for children in grades 3 and 4 and for the 1973 and 1974 school year.

next five years and personnel officers will be able to select the few new teachers needed from a large pool of applicants. It is important to keep in mind, however, that the indicator of vintage effects used in our model provides information only about the demand for teachers; it contains no information about the supply of teachers.[8/]

Weaver (1978) has presented evidence indicating that the average quality of the students preparing to be teachers in recent years has fallen (as measured by SAT scores relative to the national mean). This decline is partly due to the response of college students to the labor market conditions for teachers, and partly due to a lowering of standards by teacher training programs.

Given the disequilibrium in the labor market for teachers, it is not clear to what extent the decline in the average quality of the applicant pool will affect the quality of the teachers who are actually hired. Surely, there is a wide distribution of talent in the applicant pool. If the most talented applicants are hired to fill the relatively few teaching positions that will be open in the coming years, the quality will be high despite the decline in the average quality of the pool. However, the actual choice of applicants from the pool will depend on the extent to which high quality applicants can signal their ability, and on the extent to which school district personnel officers have the resources, skills, and incentives to find the talented applicants. Unfortunately, very little is known about school district hiring policies in periods of labor market disequilibrium.

VI. SUMMARY

In conclusion, we have argued that two factors related to labor market conditions for teachers--vintage effects and selection effects--influence

the quality of the teaching staffs in American schools. These factors tend to be related to the distribution of teaching experience in a cross-sectional sample of teachers. As a result, it is necessary to account explicitly for the influences of vintage and selection effects in estimating the impact of learning by doing on teaching effectiveness.

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FOOTNOTES

[1]Summers and Wolfe (1977) found teaching experience to be positively related to the achievement of children with high initial achievement and negatively related to the achievement of children with low initial achievement. They suggest that the latter relationship may be due to the fact that the "undampened enthusiasm" of new teachers makes them particularly effective with slow learners, while the skills developed through experience are particularly important in teaching children with above average achievement. This is certainly plausible. However, these results could also be due to a particular type of selection mechanism. Particularly effective experienced teachers may be more likely than less effective teachers to leave exhausting positions in schools serving large numbers of low achieving children because they face a more attractive opportunity set, both inside and outside the teaching profession. This selection process could explain the negative relationship between teaching experience and effectiveness in teaching children with low initial achievement. We explain such selection processes in more detail later in the paper.

[2]More general discussions of vintage effects are found in Hanushek and Quigley, 1978, and Weiss and Lillard, 1978.

[3]As we discuss in Section V, there is evidence that, at least according to some criteria, the average quality of applicants for teaching positions has fallen in recent years. This would make it more difficult for personnel officers to find talented applicants. However, our results indicate that at least for the period through the early 1970's, the average quality of the teachers who were hired was inversely related to the demand for teachers.

[4]For ease of exposition, we frame the discussion in terms of learning by doing and vintage effects. As pointed out above, however, the coefficients on the observable variables may also reflect the influence of the unobserved selection effects.

[5]The data include observations on students and teachers for the years 1973-75. We treated these data as a single cross-section because the subsamples for individual years contained too few observations to estimate equation 1.

We standardized the test scores to account for differences in the mean and variance across the two grade levels.

The result of an F test indicated no significant differences in the structure of the model between the grade 3 and grade 4 subsamples ($F = 0.77$).

[6]See Boardman and Murnane (1979) for an explanation of the reason why the specification presented in Equation 1 is preferable to a first difference specification for the dependent variable.

[7]The result of an F test indicated rejection at the .01 significance level of the hypothesis that the coefficients on the vintage and learning by doing variables were both equal to zero ($F = 4.62$).

We also estimated the model with a linear specification for learning by doing effects. The linear specification for teaching experience also resulted in a positive coefficient that was significantly different from zero. The explanatory power of the equation was marginally lower with this specification.

[8]We also attempted to construct measures of vintage effects from national data on the demand for and supply of teachers. The coefficients on these indicators had the right sign in our model, but were never

significantly different from zero. The probable reason is that the enrollment trends in the district from which our data came did not parallel the national enrollment trends. In particular, enrollments in this district peaked before they did nationally, and the enrollment declines were exacerbated by middle class flight to the suburbs.

Table A-1

Total student enrollments in the urban school district which provided the data for this analysis

1941	20,509	1961	42,057
42	20,146	62	44,145
43	20,176	63	45,845
44	20,331	64	47,376
45	20,032	65	47,582
46	19,903	66	48,046
47	20,253	67	48,271
48	20,612	68	48,509
49	21,048	69	48,299
50	21,536	70	47,618
51	22,411	71	46,546
52	23,729	72	45,273
53	25,935	73	43,687
54	28,174	74	41,680
55	30,482	75	40,034
56	33,263	76	38,241
57	35,420	77	36,963
58	37,383	78	35,498
59	39,033	79	34,032
60	39,785	80	32,753

Table A-2

STATISTICS DESCRIBING THE VARIABLES INCLUDED IN EQUATION 1

For continuous variables, the mean and, in parentheses, the standard deviation are given. For dichotomous variables, the percentage of the sample for which the variable assumes a value of one is given.

Teacher Characteristics	
Experience	14.34 (5.96)
Natural logarithm of experience (indicator of learning by doing)	2.56 (0.51)
Holds master's degree	62.46
Attended prestigious college	29.23
Teacher is male	2.46
Teacher is white	4.00
Indicator of Vintage Effects	
Student enrollments (in hundreds of students) in the school district in the year in which the teacher began work in the district minus student enrollments (in hundreds of students) in the previous year	11.15 (11.19)
Student Background Characteristics	
Student is male	50.15
Current family income (per month)	476.90 (281.23)
Student's age	9.87 (0.77)
Household head is female	68.39
Number of children in the family	4.39 (1.99)

Other Control Variables

Achievement level of child in third grade at end of previous year	159.72 (150.69)
Achievement level of child in fourth grade at end of previous year	71.60[a] (95.81)
Dichotomous variable indicating the child is in grade 3	58.15
Number of students in the sample[b]	325
Number of teachers in the sample	75

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a/ Different baseline achievement tests were administered to the third and fourth grade subsamples. This is the reason that the sample means have much different values.

b/ All of the means and standard deviations in Table A-1 were calculated using the number of student observations as weights. The number of students appears small relative to the number of teachers. The explanation is that only children whose families participated in a particular welfare reform experiment (unconnected with the school system) were included in the sample.